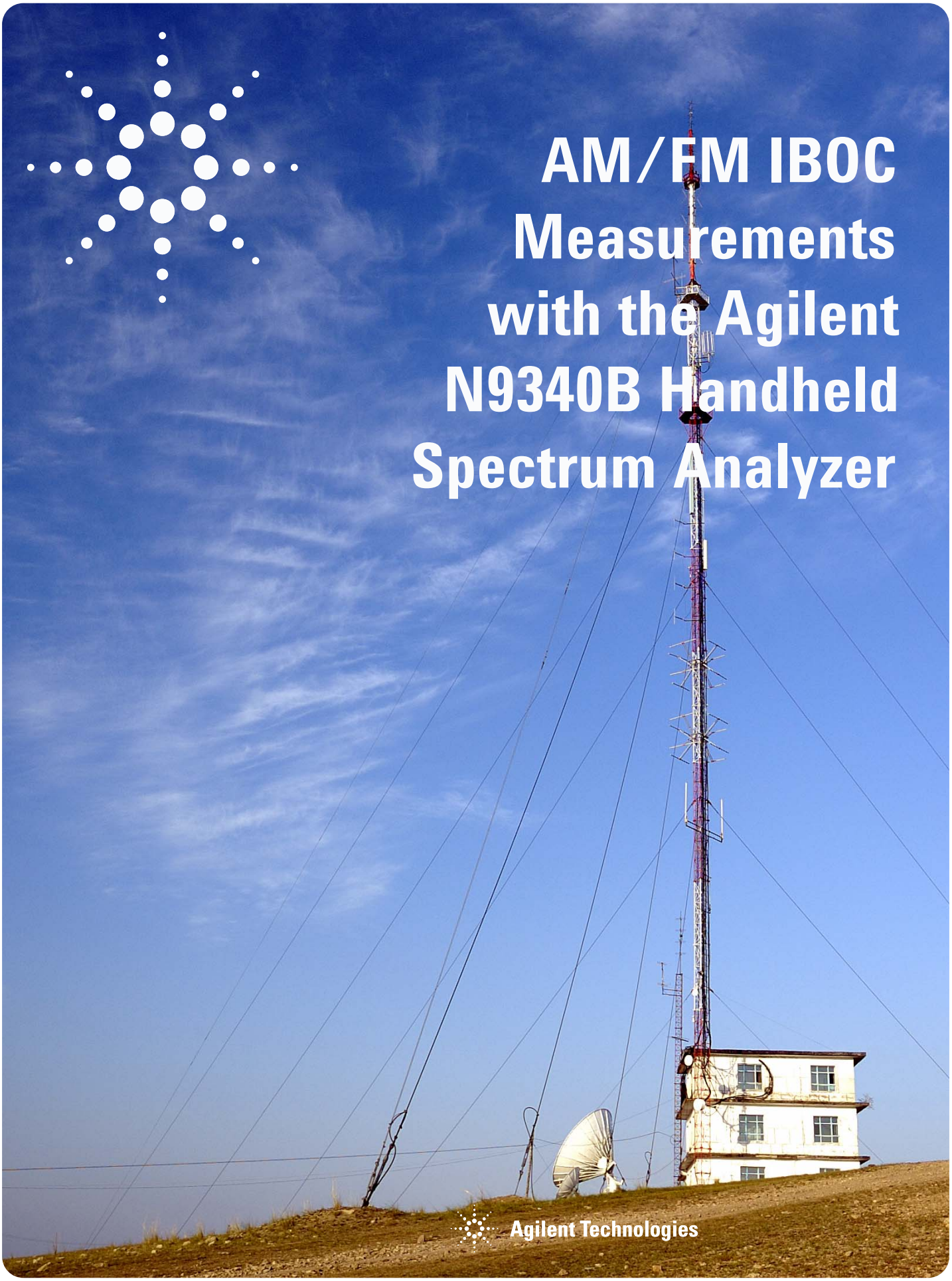
AM/FM IBOC Measurements with the Agilent N9340B Handheld Spectrum Analyzer



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Introduction

AM/FM IBOC, widely accepted as the next generation digital radio technology in many countries including US and Brazil, operates in conjunction with the existing analog AM/FM broadcast frequencies. The National Radio Systems Committee (NRSC) has published recommended standards that specify that IBOC signals, both Hybrid and All Digital, must be transmitted below the defined spectral emission limits. This requires broadcast engineers to perform spectral emission proof-of-performance testing during installation and routine maintenance. To help broadcast engineers complete those installation and maintenance tasks easier and more quickly, Agilent offers the industry's first dedicated IBOC measurement personality on the award-winning N9340B handheld spectrum analyz er, option N9340B-IBC. This document gives a brief introduction of IBOC technology and the benefits a user can realize from using the N9340B analyzer with the optional IBOC measurement personality.

What is IBOC?

IBOC stands for "In-band on-channel" and it is a method of transmitting digital radio broadcast signals centered on the AM or FM station's current analog based frequencies. IBOC technology is designed to implement a smooth evolution from current analog radio broadcasting to fully digital broadcasting and delivers digital audio and data services on existing Amplitude Modulation (AM) and Frequency Modulation (FM) radio broadcast channels. Broadcasters may continue to transmit AM and FM analog signals simultaneously with the IBOC digital signals, allowing themselves and their listeners to transition from analog to digital radio while maintaining their current frequency allocations. For AM or FM stations, the transmission of the digital signals occupies digital sidebands above and below the center of the existing AM or FM frequencies. By utilizing digital sidebands, the need for extra frequency allocation is avoided. However, this also means extra RF energy (digital sidebands) will be added beyond the edge of the station's normally-defined channel, thus potential interference with adjacent channel stations is increased when using the IBOC technique.

Spectrum emission proof-of-performance measurements for IBOC signals

To ensure reliable reception of the digital audio/data, minimize harmful spectral emissions and prevent mutual interference between broadcast stations, a group of spectral emission limits is defined in the NRSC standard NRSC-5-B for both Hybrid and All Digital transmissions. Broadcasters are required to do spectral emission proof-of-performance testing in a timely manner to verify the digital signals being broadcast are following the NRSC standards. In the case of Hybrid transmissions, NRSC has specified that the introduction of digital subcarriers shall not compromise the performance of the host analog AM/FM signals as follows: The analog signal shall meet the U.S. FCC emissions mask specifications contained in Radio and Television Broadcast Rules 47 CFR Parts 73.44 and 73.317.

IBOC measurement with Agilent N9340B handheld spectrum analyzer

The Agilent N9340B is an award-winning handheld spectrum analyzer. It provides superior performance, rich measurement features and outstanding usability in a compact form factor. The latest enhancement on the N9340B platform is option N9340B-IBC, a dedicated IBOC measurement personality that brings broadcasters superior performance and greater convenience for satisfying the NRSC specified measurements. The following is a discussion of the benefits the N9340B analyzer brings to broadcasters.

Superior performance in a Compact Size

Built on a small, portable chassis, the N9340B handheld spectrum analyzer has best-in-class performance: Sensitivity or Displayed Average Noise Level (DANL) is –144 dBm (Preamplifier on), minimum Resolution Bandwidth (RBW) is 30 Hz and Single Sideband (SSB) phase noise is –87 dBc/Hz @ 30 kHz offset. It is equipped with a very bright 6.5 inch TFT display, USB and LAN ports.

The option N9340B-IBC includes both hardware and software enhancement. With N9340B-IBC option installed, N9340B SSB phase noise is improved in AM IBOC frequencies. For FM IBOC frequencies, a noise cancellation feature is added to provide greater measurement margins.

Dedicated IBOC Measurement Mode – the MODE hardkey

With option N9340B-IBC, the N9340B becomes the industry's first handheld spectrum analyzer with a dedicated IBOC measurement personality or mode. The MODE hardkey allows the user to choose from several measurement modes. Depending on what options the user has purchased, the N9340B can operate in the following modes: Spectrum Analyzer, Power Meter, Tracking Generator, Demodulation Analysis and IBOC Measurements.

With the N9340B-IBC option installed, the user will be given two choices after entering IBOC Measurement mode: AM and FM. By selecting the appropriate choice, the instrument will activate the corresponding hardware and software.

Figure 1: N9340B IBOC Measurement Mode: AM and FM

Built-in Spectral Emission Limits (Masks)

N9340B has preloaded the AM/FM spectral emission limits (analog and IBOC). The user can easily switch between these limits. The preloaded limits include:

AM spectral emission limits

- AM-73.44 <Analog>: analog AM spectral emission limits defined in FCC standard 73.44
- AM NRSC-5-B <Hybrid 5k>: spectral emission limits for Hybrid Transmissions 5 kHz mode Analog Bandwidth defined in NRSC-5-B
- AM NRSC-5-B <Hybrid 8k>: spectral emission limits for Hybrid Transmissions 8 kHz mode Analog Bandwidth defined in NRSC-5-B
- AM NRSC-5-B <All Digital>: spectral emission limits for All Digital Transmissions defined in NRSC-5-B

FM spectral emission limits

- FM-73.317 <Analog>: analog FM spectral emission limits defined in FCC standard 73.317
- FM NRSC-5-B <Hybrid>: spectral emission limits for Hybrid Transmissions defined in NRSC-5-B
- FM NRSC-5-B <All Digital>: spectral emission limits for All Digital Transmissions defined in NRSC-5-B

The N9340B allows the user to customize their own spectral emission limits with the built-in limit editor. Two edit modes are provided: "Limits Points" mode allows user to "draw" the limits by moving the limits points around on the screen while "Limits Table" mode lets the user key the frequency and amplitude of each limit point into a table. The user can even toggle between the two modes while customizing the spectral emission limits. For users who also utilize Agilent ESA series spectrum analyzers, Agilent has made available, at no-charge, N9340B PC software to convert between ESA and N9340B limits.

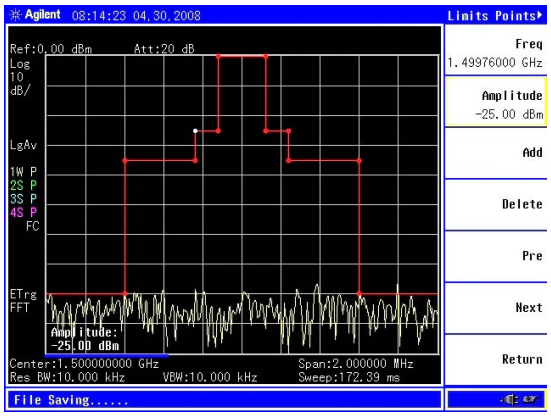

Figure 2: Editing limits in Limits Table mode

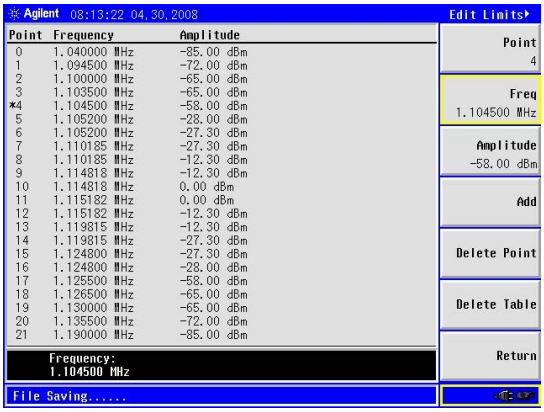

Figure 3: Editing limits in Limits Table mode

The spectral emission limits have a Pass/Fail indicator which can be turned on to facilitate the measurement. A defeatable, audible beep alert is also provided.

Auto Tune

An Auto Tune function is embedded in the IBOC Measurement mode which automatically sets the reference level and center frequency thus freeing users from complicated instrument set-ups. Setting up a spectrum analyzer for NRSC measurements used to be complex because of the different definitions of the 0 dBc reference point. 0 dBc, which refers to the top limit line of the mask, has different definitions for different spectral emission limits. For example, In AM NRSC-5-B <Hybrid 5k> and AM NRSC-5-B <Hybrid 8k>, 0 dBc is defined as the total power of the unmodulated analog AM carrier, while in FM NRSC-5-B <All Digital> 0 dBc is defined as the nominal power spectral density in a 1 kHz bandwidth of the digital Primary sidebands. The Auto Tune function searches the largest signal in the Tune range and calculates out the appropriate reference level and center frequency. With the Tune Range soft-key the user can quickly auto tune within the current SPAN or the entire AM/FM band.

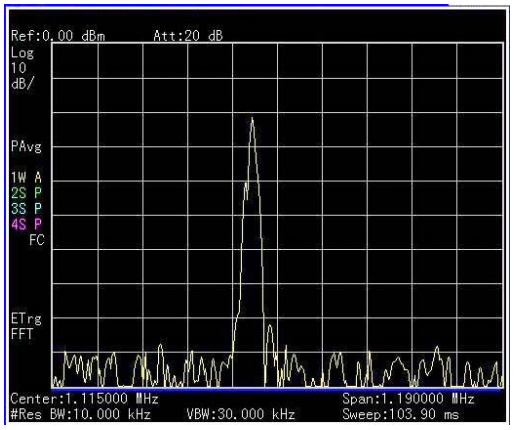

Figure 4: Before Auto Tune

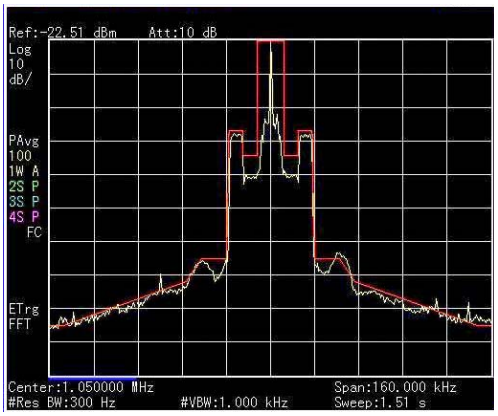

Figure 5: After Auto Tune, showing the signal optimized for the measurement and the selected limit line mask.

Channel List

Service engineers are often required to maintain several radio stations which transmit at different frequencies and power levels. They may be asked to do a series of measurements with different parameters for each station. With the N9340B IBOC Measurement personality, users can save the measurement settings in a Channel file. The Channel file can be reloaded, deleted and copied as needed. The Channel list function enables engineers to more quickly set up their instruments and complete the required measurements. Another scenario is one where a technical manager could save a series of Channel files and then distribute those Channel files to local service engineers to utilize without them having to go through an additional training procedure. When the local service engineers are on the sites, they can simply load the manager's Channel file and then do Auto Tune to quickly locate the signals of interest.

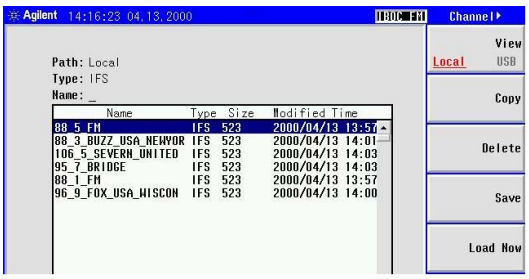

Figure 6: Channel List

Resolution Bandwidth (RBW) / Video Bandwidth (VBW) / Detector

NRSC-5-B standard documents specify that the AM IBOC measurement is to be made in "a 300 Hz bandwidth" and FM IBOC measurement in "a 1 kHz bandwidth". The N9340B analyzer has the widest range of RBW support in its class: 30 Hz to 1 MHz in a 1-3-10 sequence. Besides the specified RBW in the standards, the user can choose a different RBW for a better trade-off between sensitivity, selectivity and sweep time.

In FCC standard 47 CFR 73.44 AM transmission system emission limitations, video filtering is required to be off. This applies to older and even, many current spectrum analyzer models because VBW filtering may cause measurement errors up to 2.51 dB on those spectrum analyzers. For these analyzers, VBW must to be set much wider (three or more times) than RBW. Modern Agilent spectrum analyzers, like the N9340B and benchtop products like PSA and MXA, are FFT-based spectrum analyzers and do not have this problem. If the user still wants to turn VBW off, they just need to set VBW = RBW or VBW > RBW. In FFT analysis, a number of FFT averages are set to create a similar effect (variance reduction) as video filtering achieves in swept analysis. When VBW = RBW or VBW > RBW, that average number is just one (no averaging) thus the video filtering is off.

The N9340B provides the "average" detector with three average types: Power, Log and Voltage. Power average is the right choice for IBOC spectral emission limit testing because we are measuring the average power spectral density. The average Power detector is also called "RMS" because it is the equivalent of filtering on an RMS voltage scale. Older spectrum analyzers do not have an average detector and must use the sample detector with heavy trace averaging on a power scale. For noise-like signals like the digital sidebands of IBOC signals, the same level of variance can be achieved faster with the average detector.

More than Spectral Emission Testing

Besides the fast and easy measurements for IBOC spectral emission proof-of-performance testing, the Agilent N9340B handheld spectrum analyzer provides a wide range of additional benefits to broadcast engineers:

Usability
- 6.5'' bright, TFT color LCD for indoor and outdoor use
- 4-hour battery operating time
- Remote control via SCPI language on USB and LAN ports
- Multi-language user interface: 11 languages

Standard Features
- One-button power measurements: Channel power, ACPR, and OBW
- Spectrogram for continuous signal monitoring
- AM/FM radio tune and listen
- Agilent USB power sensor U2000 series support for power meter measurements
- Field strength measurements

Optional features
- AM/FM and ASK/FSK modulation analysis
- 3 GHz pre-amplifier for increased sensitivity
- 3 GHz tracking generator for scalar network analysis

Recommended Configuration

N9340B	Handheld spectrum analyzer 100 kHz to 3.0 GHz
N9340B-IBC	AM/FM In-Band On-Channel IBOC Measurement
N9340B-PA3	3 GHz preamplifier
N9340B-BAT	Spare battery pack
N9340B-1DC	Automotive 12 VDC adaptor

References
[1] NRSC-5-B In-band/on-channel Digital Radio Broadcasting Standard April, 2008
[2] HD Radio FM Transmission System Specifications, iBiquity Digital Corporation, 1/30/08
[3] HD Radio AM Transmission System Specifications, iBiquity Digital Corporation, 1/30/08
[4] Performance Standards and Measurement Techniques Using Spectrum Analyzers for In-Band On-Channel Transmitters, still in draft form, with the NRSC IBOC Standards Working Group as of May 9, 2008

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